Chapter 7.1
Exploratory Analysis of Fossil-Fuel CO_2 Emissions Time Series Using Independent Component Analysis

Sargam Parmar
Ganpat University, India

Bhuvan Unhelkar
University of Western Sydney & MethodScience, Australia

ABSTRACT

Carbon dioxide (CO_2) is one of the most important gases in the atmosphere, and is necessary for sustaining life on Earth. However, it is also a major greenhouse gas out of the six that contribute to global warming and climate change. During the last decade technologists, economists and sociologists are taking substantial interest in studying the impact of greenhouse phenomenon. Scientists are trying to find solutions to reduce CO_2 emissions by changes in structure of energy production and consumption. Every attempt is being made to use new models and methods to estimate measure and monitor greenhouse gases in the future. Independent Component Analysis (ICA) is a method for automatically identifying a set of underlying factors in a given data set. This chapter describes the use of the ICA algorithm in Environmentally Intelligent (EI) applications. EI applications have a wide ranging responsibilities including collection, analysis and reporting of environmental data related to the organization. ICA algorithm opens up the opportunity to improve the quality of data being analyzed by these EI applications. ICA finds application in several fields of interest and it is a tempting alternative to try ICA on multivariate time series such as a CO_2 emission from fossil fuel for the period 1950 to 2006. This chapter describes the linear mapping of the observed multivariate time series into a new space of statistically independent components (ICs) that might reveal driving mechanisms for CO_2 emissions that may otherwise remain hidden.

DOI: 10.4018/978-1-60960-472-1.ch701

INTRODUCTION

Carbon dioxide (CO_2) is one of the most important gases in the atmosphere, and is necessary for sustaining life on Earth. However, it is also a major greenhouse gas out of the six (http://www.epa.gov/climatechange/emissions/) that contribute to global warming and climate change. During the last decade technologists, economists and sociologists are taking substantial interest in studying the impact of greenhouse phenomenon. Scientists are trying to find solutions to reduce CO_2 emissions by changes in structure of energy production and consumption. Every attempt is being made to use new models and methods to estimate measure and monitor greenhouse gases in the future. Independent Component Analysis (ICA) is a method for automatically identifying a set of underlying factors in a given data set. This chapter describes the use of the ICA in Environmentally Intelligent (EI) applications (see Unhelkar and Trivedi, 2009) that will improve the quality of data being analyzed by these EI applications. This rapidly evolving technique is currently finding applications in several fields of interest and it is a tempting alternative to try ICA on multivariate time series such as a CO_2 emission from fossil fuel for the period 1950 to 2006. The key idea here is to linearly map the observed multivariate time series into a new space of statistically independent components (ICs) that might reveal some driving mechanisms that may otherwise remain hidden.

Estimates of the amount of carbon emitted in to the atmosphere from fossil-fuel burning produce can be considered as a basic time-series in this context. Different kinds of time-series have been recorded and studied. Nowadays, all transactions on carbon emitted to the atmosphere from fossil-fuel burning are recorded, leading to a huge amount of data available, either freely or commercially on the Internet.

Furthermore, the stochastic uncertainties inherent in fossil-fuel CO_2 emissions time-series and the theory needed to deal with them make the subject especially interesting not only to economists, but also to statisticians and physicists. Fossil fuel CO_2 emissions systems is a complex evolved dynamic system with high volatility and noise. Due to its irregularity, fossil fuel CO_2 emissions time series forecasting is regarded as a rather challenging task. CO_2 emission estimate systems require more advanced signal processing methods, and correct reception of CO_2 emission time series is more difficult because of several phenomena such as annual global CO_2 emissions from solid fuels, liquid fuels, natural gas, gas flaring, and cement manufacturing.

This chapter describes the use of the Independent Component Analysis (ICA) in Environmentally Intelligent (EI) applications that will improve the quality of data being analyzed by these EI applications. ICA is a method for automatically identifying a set of underlying factors in a given data set. This rapidly evolving technique is currently finding applications in several fields of interest and it is a tempting alternative to try ICA on multivariate time series such as a CO_2 emission from fossil fuel for the period 1950 to 2006. The key idea here is to linearly map the observed multivariate time series into a new space of statistically independent components (ICs) that might reveal some driving mechanisms that otherwise remain hidden.

The chapter is organized as follows. Section 2 provides a background to ICA and a guide on how to estimate the independent components. Section 3 discusses some issues concerning the general application of ICA to CO_2 emission from fossil fuel. Results are shown for global CO_2 emission in general and specifically for India's CO_2 emission in section 4. Finally, section 5 concludes the chapter with a discussion and thoughts on future directions.